CENTRALIZED AIR CONDITION SYSTEM'S COEFFICIENT OF PERFORMANCE AND RELATIONS WITH ENERGY USAGE AT LAMAN HIKMAH LIBRARY UTEM

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Centralized Air Condition System’s Coefficient of Performance and relations with Energy Usage at Laman Hikmah Library UTeM” is the result of my own work except as cited in the references

Signature : .....

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Hons).

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DEDICATION

To my beloved mother and father

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ABSTRACT

The sole purpose of this thesis is to conduct an analysis regarding the centralized air conditioning system's coefficient of performance (COP) in relation with energy usage at Laman Hikmah UTeM. Laman Hikmah is one of the leading building in energy consumption at UTeM. The use and energy production has a huge impact on the climate and climate change will affect our capacity for generating energy and our demands for energy. Air conditioning system in Laman Hikmah is dramatically increasing day by day. Thus, it is particularly important to understand the detailed energy consumption structure in that building, focusing especially on air conditioning usage. Library UTeM was established as a new building at the main Campus, Durian Tunggal on 8 July 2009. It started its operation on 29 September 2009. The Library Gross Floor Area (GFA) is 14,503.64 m^2, Net Floor Area (NFA) is 7977.00 m^2 (55% from GFA) and the Air Conditioning Area (ACA) is 13,053.28 m^2 (90% from GFA) could provide a seating capacity of 500 users at any one time. This library have 66 staffs. The building main energy supply are in the form of electricity from TNB (100%) with C1 tariff. The annual electricity consumption for August 2014 until July 2015 was 1,374,110 kWh. Two chillers operate during the audit process with the COP is 4.4 respectively. Other heat rejection device is cooling tower (CT). Based on overall energy consumption baseline (July 2014-June 2015), it was discover that Laman Hikmah consumed total of 8% of energy from UTeM. Then chiller of Laman Hikmah itself consume about 50% energy compare to other energy sources of the library. In an order to find out the coefficient of performance of chiller, some data was measured and analyzed such as Chiller Water Supply (CHWS) temperature, Chiller Water Return (CHWR) temperature, flowrate, and power consumption of the chiller. The overall energy consumption data of Laman Hikmah was gathered via available Internet of Things (IoT) energy management tools and compared with the manually gathered and also with the projected baseline data. A statistical regression analysis is then used to analyze the relation between the COP and energy consumption. Finally, the analyzed data is visualized in a graphical form to be further discussed. As a result, it was noticed that there is a relationship between COP and energy consumption. Then the collected data was compared using ASHRAE table and noticed that the system's performance is in a good state. Analysis result also shows that, as the Coefficient of Performance increases, the energy consumption decreases and well as the cost of electricity. This also have been proven in this thesis whereby, the highest power consumption by the chiller is 117.62kW with the lowest COP of 3.67, and the lowest power consumption by the chiller is 92.88kW with the highest COP of 5.55. It is essential to carryout energy audit and calculate the COP in an order to find out the chiller's performance.

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ABSTRAK

Tujuan utama tesis ini adalah untuk melakukan analisis mengenai pekali prestasi sistem penghawa dingin terpusat (COP) yang berkaitan dengan penggunaan tenaga di Laman Hikmah UTeM. Laman Hikmah adalah salah satu bangunan terkemuka dalam penggunaan tenaga di UTeM. Penggunaan dan pengeluaran tenaga memberi kesan besar terhadap iklim dan perubahan iklim akan mempengaruhi keupayaan kita untuk menjana tenaga dan permintaan kita untuk tenaga. Sistem penyaman udara di Laman Hikmah semakin meningkat dari hari ke hari. Oleh itu, sangat penting untuk memahami struktur penggunaan tenaga terperinci di bangunan itu, dengan fokus terutamanya pada penggunaan penyaman udara. Perpustakaan UTeM didirikan sebagai bangunan baru di Kampus utama, Durian Tunggal pada 8 Julai 2009. Ia mula beroperasi pada 29 September 2009. Kawasan Lantai Kasar Perpustakaan (GFA) adalah 14,503,64 m^2, Luas Lantai Bersih (NFA) adalah 7977,00 m^2 (55% dari GFA) dan Kawasan Penyaman Udara (ACA) adalah 13.053.28 m^2 (90% dari GFA) dapat memberikan kapasitas tempat duduk 500 pengguna pada satu-satu masa. Perpustakaan ini mempunyai 66 kakitangan. Bekalan tenaga utama bangunan adalah dalam bentuk elektrik dari TNB (100%) dengan tarif C1. Penggunaan elektrik tahunan untuk Ogos 2014 hingga Julai 2015 adalah 1,374,110 kWh. Dua pendingin beroperasi semasa proses audit dengan COP masing-masing 4.4. Peranti penolakan haba lain adalah cooling tower (CT). Berdasarkan garis dasar penggunaan tenaga secara keseluruhan (Julai 2014-Jun 2015), didapati bahawa Hikmah menggunakan 8% tenaga dari UTeM. Kemudian pendingin Laman Hikmah sendiri menggunakan sekitar 50% tenaga berbanding dengan sumber tenaga lain di perpustakaan. Untuk mengetahui pekali prestasi chiller, beberapa data diukur dan dianalisis seperti suhu Chiller Water Supply (CHWS), Chiller Water Return (CHWR), flowrate, dan penggunaan daya chiller. Keseluruhan data penggunaan tenaga Laman Hikmah dikumpulkan melalui alat pengurusan tenaga Internet of Things (IoT) yang tersedia dan dibandingkan dengan data yang dikumpulkan secara manual dan juga dengan data asas yang diproyeksikan. Analisis regresi statistik kemudian digunakan untuk menganalisis hubungan antara COP dan penggunaan tenaga. Akhirnya, data yang dianalisis dipvisualisasikan dalam bentuk grafik untuk dibincangkan lebih lanjut. Akibatnya, diperhatikan bahawa ada hubungan antara COP dan penggunaan tenaga. Kemudian data yang dikumpulkan dibandingkan dengan menggunakan jadual ASHRAE dan melihat bahawa prestasi sistem berada dalam keadaan baik. Hasil analisis juga menunjukkan bahawa, apabila Pekali Prestasi meningkat, penggunaan tenaga menurun dan juga kos elektrik. Ini juga telah dibuktikan dalam tesis ini di mana, penggunaan kuasa tertinggi oleh chiller adalah 117.62kW dengan COP terendah 3.67, dan penggunaan kuasa terendah oleh chiller adalah 92.88kW dengan COP tertinggi 5.55. Adalah mustahak untuk menjalankan audit tenaga dan mengira COP untuk mengetahui prestasi chiller.

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LIST OF ABBEREVATIONS

HVAC	Heating Ventilation Air Conditioning
NFA	Net Floor Area
COP	Coefficient of Performance
VCR	Vapor Compression Refrigerant
WLHP	Wick-mounted Heat Loop
AHU	Air Handling Unit
AC	Air Conditioner
CT	Cooling Tower
CHWP	Chiller Water Pump
CHDP	Condenser Water Pump
CHWS	Chill Water Supply
CHWR	Chill Water Return
IoT	Internet of Things
EER	Energy Efficiency Ratio
VFD	Variable Frequency Drives

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LIST OF SYMBOL

η_{th} = Thermal efficiency

W = Work done

Q = Flowrate

T = Temperature

T_{out} = Temperature return

T_{in} = Temperature supplied

Q_H = Heat input at high temperature

Q_{hot} = Heat gain

Q_{cold} = Heat released

ΔP = Changes in Pressure

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CHAPTER 1

INTRODUCTION

1.1 Background

The average global temperature has risen at the fastest rate in recorded history over the past 50 years. Yet experts see the trend is accelerating. Hansen (2015) states that Global warming occurs when carbon dioxide, CO_2 and other air pollutants and greenhouse gases collect in the atmosphere, absorb sunlight, solar radiation that have bounced off the earth's surface. This radiation will usually disperse into space, but these pollutants, which can last in the atmosphere for years to decades, trap the air and make the earth hotter. 'Global warming' is a term referring to the environmental impact of human activities, in particular the burning of fossil fuels (coal, oil and gas) and large-scale deforestation, causing large quantities of' greenhouse gas' pollution into the environment, the most important of which is carbon dioxide. Global warming's effects were felt across the globe. In recent years, extreme heat waves have caused tens of thousands of deaths worldwide. Every year, researchers learn more about the effects of global warming and many believe that if current trends continue, ecological, economic and health implications will likely occur. The increasing heat-trapping gases emitted by human activities into the atmosphere produce an energy imbalance between incoming solar radiation and outgoing long wave radiation that leads to global heating (Von Schuckmann et al. 2016). If energy never managed well, then it's really hard to overcome global warming issues.

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Energy is one of the most imperative aspects of technological advancement in the state. Sustainable development includes efficient energy use and savings. The energy saving process is called energy management. Saving energy is essential for saving planet. Fossil fuels and conventional energy sources are the primary sources of energy. Thus energy management is a global concern. It's necessary to reduce the planet's damage. Shafie et al. (2011) found that the economic growth is measure by gross domestic product (GDP) and in Malaysia GDP is correlates almost exactly with the energy consumptions of the country. In the last 28 years, primary energy consumption has increased by an average of 6.8% and electricity consumption by 9.2% annually in Malaysia.

According to Malaysia energy statistic handbook 2018, the primary production of fuel on year 1996 is total 76,171 ktoe and increased by 102,801 ktoe in 2016. In this era with limited resources, conservation and energy efficiency continue to be major challenges. The application of energy conservation techniques in air conditioning systems must be matched with the convenience and safety of the occupants. There were few specific guidelines on energy savings in air conditioning systems, but these recommendations do not satisfy all specifications and model varieties. Air Conditioning use is expected to be the second largest source of growth in global electricity demand and the main driver of buildings by 2050. The supply of energy to these Air Conditioning involves significant costs and environmental consequences. Diversity of Air Conditioning usage behavior among residents is the main cause of the variation in heating energy consumption (Goetzler, 2016).

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1.2 Problem Statement

The global climate is changing, posing ever more serious risks to biodiversity, human health, and the economy. All around the world already experiencing climate change impacts, including rising sea levels, more extreme weather, floods, droughts and storms. Globally, energy consumption is by far the largest source greenhouse gas emissions by human activities. Approximately two-thirds of global greenhouse gas emissions are related to the burning of fossil fuels for heating, electricity, transportation and industrial use. The use and energy production has a huge impact on the climate and climate change will affect our capacity for generating energy and our demands for energy.

Laman Hikmah Library UTeM as shown in Figure 1.1., is one of the leading building in energy consumption at UTeM, its total NFA is 7,977.00m² and have 66 staffs and 500 users capacity. Laman Hikmah Library UTeM is a curated collection of information sources and chosen by students for reference and borrowing purposes of books. Air conditioning system in Laman Hikmah is dramatically increasing day by day. Thus, it is particularly important to understand the detailed energy consumption structure in that building, focusing especially on air conditioning usage. So this thesis attempts to figure out the centralized and split unit air condition system's coefficient of performance and relations with energy usage at Laman Hikmah Library UTeM.

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Figure 1.1 : Laman Hikmah Library UTeM

1.3 Objective

The objectives of this thesis are as follows:

1. To obtain the measurement of the Centralized Air-conditioning system's energy consumption at the building Laman Hikmah Library UTeM.
2. To establish the relationship between the power consumption and coefficient of performance of Air conditioning at Laman Hikmah Library UTeM.

1.4 Scope

The scopes of this thesis are:

1. The comparison of energy consumption at Laman Hikmah with other UTeM buildings by using IoT baseline data.
2. Analyzing the COP of chiller system and obtain the relationship with energy consumption in Laman Hikmah Library UTeM
3. Provide necessary measures to improve the system's performance.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

General air conditioning can be supported by a range of devices varying from low-horsepower self-contained systems to several thousand tons of very large built-up central systems. The primary goal of user is to obtain and use an air conditioning system that delivers the most suitable performance in terms of capital, operating, substitution and operating costs on a life-long basis (Bhatia, A., 2011).

The Vapour-compression cooling system uses a flowing fluid refrigerant as the operating medium that collects then separates the heat from the cooling region and then returns it into the atmosphere. Vapour Compression Refrigerant (VCR) process performance is determined as a coefficient of performance (COP). If COP is greater, the device absorbs more energy and is therefore more effective for a particular work input (Nethaji, N., 2017).

Air conditioning device incorporated wick-mounted loop heat pipes (WLHP). The WLHP is on the air conditioning unit's evaporator side. The WLHP's operating medium is R134a coolant gas, an alternative coolant (Hussam, 2013). The WLHP is a system that enables very significant heat transfer across huge distances across small surface spaces, with minimal differences in temperature and no external pumping energy. Usually the WLHP consists of heavy thermal conductivity products such as copper, aluminium and brass based on the usability of the operating medium and the implementation range of temperatures. For quicker heat removal, the condenser portion is bigger in size compared to the evaporator

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(Hatem, 2012). Likewise, the diameter of the vapour loop is greater than the diameter of the water loop for smoother flow of lighter vapour than the denser working fluid. Due to thermo siphon effect, the vapour that flows through the vapour loop enters the WLHP condenser portion, where the heat is rejected and the liquid is saturated at the same pressure and temperature and flows down through the liquid loop to the evaporator column (Tharves, 2017).

2.2 Laman Hikmah UTeM

Universiti Teknikal Malaysia Melaka (UTeM) was founded as a consequence of the rebranding of Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) Section 8 of the University and College University Act 1971 (Act 30), published as P.U. (A) 45/2007, 1 February 2007. The UTeM Library has been in service at the Temporary Campus in Taman Tasik Utama, Ayer Keroh, Melaka, serving 348 groundbreaking students since 10 June 2001 (Hafiz, 2018).

Laman Hikmah Library was moved to the Industrial Campus on September 5, 2005 from the Temporary Campus, which started operating on September 12, 2005. Laman Hikmah Library will fill about 400 occupants with an area of 2,229 square meters. In addition, the Main Laman Hikmah Library, 432 square meters, has for 120 sitting capacity users to meet students needs from both the Faculty of Electrical Engineering (FKE) and the Faculty of Electronics and Computer Engineering (FKEKK).

The Laman Hikmah Library has a seating capacity of 500 users at any time on the Main Campus (10,063.68 square meters). Laman Hikmah Library has a maximum collection of over 115,000 titles comprising 13 registered titles addressing the core areas of Electrical

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Engineering, Electronics and Computer Engineering, Mechanical Engineering, Industrial Engineering, Engineering, Information and Communication Technology and Knowledge Creation & Technopreneurship. Other scientific fields such as physics, chemistry and mathematics are also available as well as general readings (Razak, 2018).

Tenaga Nasional Berhad (TNB) electricity is the main source of energy for the tower. The input of diesel fuel to the generator array is not known to be a building energy source. Library is committed to providing outstanding information tools and guides, as well as providing quality facilities in accordance with the university's vision and mission, using the latest technology (Tahir, 2018).

The building usually runs about 14 hours a day from Monday to Friday from 8.00 AM to 10.00 PM and operates around 5 hours a day on weekends from 10.00 AM to 3.00 PM. Nevertheless, spaces such as book or file storage room are run 24 hours a day. Since the building was first occupied, there has been no significant retrofit and re-commissioning. Nonetheless, in order to accommodate different requirements of each floor, some interior renovations were made (Sulaima, 2018).

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